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(ORIGINAL)

FOR OFFICE USE

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Related Art :

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Complete Specification for the invention entitled :

IMPROVEMENTS IN LOW-PROFILE ANTENNAS

The following statement is a full description of this invention, including the best method of performing it known to me :-

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The invention relates to low-profile antennas.

Some types of low-profile antennas are shown schematically in Figures 1, 2 and 3.

Figure 1 represents a typical transmission line antenna consisting of a straight conductor MC placed parallel to a conducting surface G at the distance H. F is a coaxial feeder; its outer conductor is connected to the conducting surface G. Its inner conductor feeds the vertical conductor AB, which is connected at B to the horizontal transmission line conductor MC. The conductor MC operates as an unbalanced transmission line above the conducting surface G. The transmission line antenna, Figure 1, is open-circuited at the end C, and short-circuited at the end M by means of the conducting member MN. Other types of transmission line antennas are feasible where both ends, C and M, are short-circuited, or open-circuited, or suitable impedances are connected between the ends M, C, and the conducting surface G.

The spacing H, Figure 1, is a small fraction of a wavelength. The section lengths, S_m and S_c, are selected so that a specified input resistance or also a specified input reactance at feed point B or at point A are obtained. The total length

$$MC = S_m + S_c = S$$

in the antenna of Figure 1, is approximately one quarter wavelength, but may be distinctly shorter or longer than a quarter wavelength to satisfy design specifications.

The conductor sections MN and AB are radiators of waves polarized parallel to AB and MN.

A small amount of radiated power is polarized parallel to the conducting surface G.

Figure 2 shows schematically a transmission line antenna with a folded conductor. It can be derived from the type of Figure 1 by

folding the conductor MC so that the length CE, Figure 2, is about twice the length MD; the section DE is relatively small. Radiation of waves polarized parallel to G, is considerably lower than that radiated from MC, of Figure 1, under equal conditions.

Figure 3 shows schematically a transmission line antenna designed for low or very low frequencies. The transmission line conductor MC is bent at D and E so that the antenna can be suspended between three masts. The folding of the transmission line conductor MC has an effect similar to the folding of the conductor in the type shown in Figure 2, namely reduction of horizontally polarized radiation. The transmission line conductor MDEC may consist of a number of parallel wires, arranged in a plane or forming a cage conductor so that a relatively low characteristic impedance is achieved. The transmission line conductor is conductively connected at M to a grounded mast MN, but is electrically isolated from the other masts M_1N_1 and M_2N_2 by means of insulators K at D and E, so that the transmission line conductor MDEC is short-circuited at M and open-circuited at C where an insulator K separates it from the mast MN.

The lengths of the short-circuited transmission line section BM and of the open-circuited section BDEC in Figures 2 and 3, correspond to S_m and S_c of Figure1. They determine the input resistance and the input reactance at feed points B or A.

The bandwidth of transmission line antennas of Figures 1, 2, and 3, is rather narrow.

The objective of the invention is to increase the bandwidth of transmission line antennas, and/or to control or eliminate the input reactance.

The principle of the invention is as follows :

The transmission line conductor of a transmission line antenna or a part of it is replaced by two or more separate conductors of different

lengths, and of equal or different cross sections. This construction can be used to obtain a wider control of the input impedance and/or an increased bandwidth of the antenna.

Figure 4 shows an example incorporating the principle of the invention. A section of the transmission line conductor is split up into two parallel conductors of different lengths, UC' and UC, whereby the latter is longer than the former. The structure becomes electromagnetically more effective when point U is chosen closer to the feed point B. Particularly useful is a design wherein point U coincides with the feed point B.

A very flexible design of a low-profile antenna incorporating the invention is shown schematically in Figure 5. One or more of the sections M'N', M'B', B'C', may differ from the corresponding sections MN, MB, BC. Other desirable effects can be obtained when suitable networks X, X', are inserted in the feeder lines AB, AB', respectively.

Low-profile antennas with a conductor folded as in Figure 2, can be designed according to the principle of the invention. The folded type can be derived from Figure 5 by bending both conductors B'C' and BC in horizontal planes, for instance clockwise, to obtain U shapes for each conductor.

A very favourable construction is obtained when one conductor is bent clockwise and the other anticlockwise as shown schematically in plan view in Figure 6.

Another example according to the invention is shown schematically in plan view in Figure 7. The short-circuiting member MN is common to both transmission line conductors MDEC and MD'E'C'. The transmission line conductors are driven at B and B', respectively.

The principle of the invention can be applied to a low frequency antenna similar to Figure 3. The conductor MDEC has to be replaced by two

conductors which are conductively separated in accordance with the invention, whereby some corresponding sections differ in length. A part of the transmission line conductor of a low frequency antenna incorporating the invention is shown in plan projection in Figure 8. BDE is part of a conductor MBDEC, and B'D'E' is part of a conductively separated conductor M'B'D'E'C', as can be visualized by inspecting both Figures 3 and 8. The conductor M'C' is electrically shorter than conductor MC. If a single short-circuiting mast, MN, is used, M' coincides with M.

A very useful low-profile antenna is obtained when any of the antennas described with reference to Figures 4, 5, 6, 7 and 8, is constructed so that the lengths of following corresponding sections are equal :

$$\left.\begin{aligned} M'N' &= MN \\ M'B' &= MB \\ A\,B' &= AB \end{aligned}\right\} (1)$$

but the total length of the transmission line conductors is given by

$$MC = (1 + u)\,\lambda/4 \qquad (2)$$

$$M'C' = (1 - v)\,\lambda/4 \qquad (3)$$

where v is equal to or very little different from u , and both quantities u and v , are small compared with unity. Therefore MC is longer and M'C' shorter than a quarter wavelength by about the same amount. This application of the principle of the invention provides a compensation of the reactances with respect to points B and B', and an additional advantage is obtained when B and B' are conductively connected.

The design equations (1) to (3) will be particularly useful for the design of antennas for low frequencies and very low frequencies as described by Figure 8 in conjunction with Figure 3.

An example of a low-profile antenna incorporating the invention which comprises more than two parallel conductors is shown in

perspective view in Figure 9. The antenna consists of four parallel conductors of different lengths. Mutual effects can be reduced if the lengths of the conductors are selected according to the following inequalities

$$BC_1 > BC_2 > BC_3 > BC_4$$

In some applications of the invention it may be practical to give the parallel conductors the same physical length and to insert suitable reactances between the ends C and/or C' and the conducting base surface G, in the types of Figures 4 to 7. In the low frequency and very low frequency antenna, described by Figures 3 and 8, the required reactances can be placed across the insulator between C and M, and/or between C' and M.

The application of the invention produces transmission line antennas of wider bandwidth or of better frequency response, compared with transmission line antennas consisting of a single conductor.

There are many other designs feasible in accordance with the principle of the invention. Conductors which are electrically parallel connected need not be geometrically parallel. An example is shown schematically in Figure 10. It may be designed according to the relations

$$BM' = BM, \; M'N' = MN,$$
$$BC' < BC,$$

in accordance with the invention.

The claims defining the invention are as follows :

Claim 1. A radio frequency transmission line antenna consisting of two or more electrically parallel conductors of different lengths, each conductor situated a fraction of a wavelength distant from a common conducting surface, one end of said each conductor connected by a conducting member to the conducting surface, and each conductor driven at a point some distance from the conductor's ends.

Claim 2. A radio frequency transmission line antenna as claimed in Claim 1 wherein the electrically parallel conductors are also geometrically parallel.

Claim 3. A radio frequency transmission line antenna as claimed in Claim 2 wherein the sections of all conductors between the feed points up to and including the conducting members are replaced by a single conductor and single member connecting said conductor to the conducting surface, with a plurability of conductors of different lengths situated between the common feed point and the open ends of said conductors.

Claim 4. A radio frequency transmission line antenna as claimed in Claim 2 and 3 wherein the conductors of different lengths are bent whilst remaining a fraction of a wavelength distant from the conducting surface.

Claim 5. A radio frequency transmission line antenna as claimed in Claim 3 and as described and shown in Figure 4 of the drawings.

Claim 6. A radio frequency transmission line antenna as claimed in Claim 2 as described and as shown in Figure 5 of the drawings.

Claim 7. A radio frequency transmission line antenna as claimed in Claim 4 and as described and shown in Figure 6 of the drawings.

Claim 8. A radio frequency transmission line antenna as claimed in Claim 4 and as described and shown in Figure 7 of the drawings.

Claim 9. A radio frequency transmission line antenna as claimed in Claim 4 and as described and shown in Figure 3 and 8 of the drawings.

Claim 10. A radio frequency transmission line antenna as claimed in Claim 2 and as described and shown in Figure 9 of the drawings.

Claim 11. A radio frequency transmission line antenna as claimed in Claim 1 wherein the conductors of different lengths are driven at a common feed point as described and as shown in Figure 10 of the
8 drawings.

Dated this 7th Day of May, 1973.

Antenna Engineering Australia Pty. Limited.

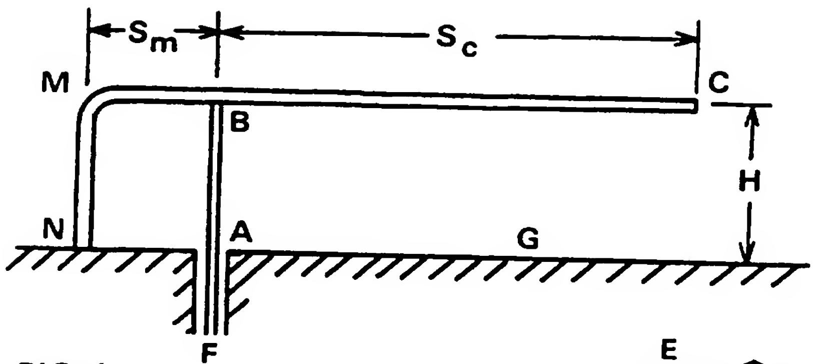

FIG 1

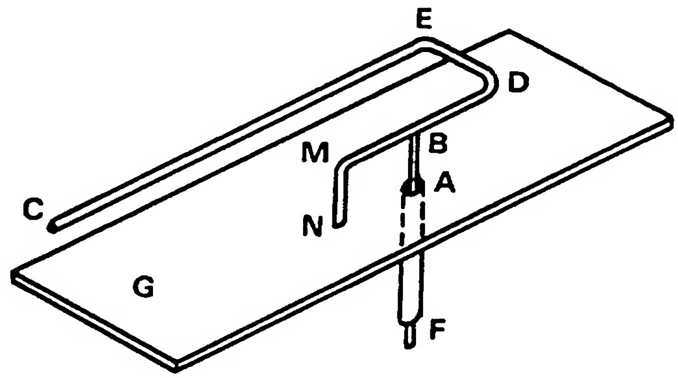

FIG 2

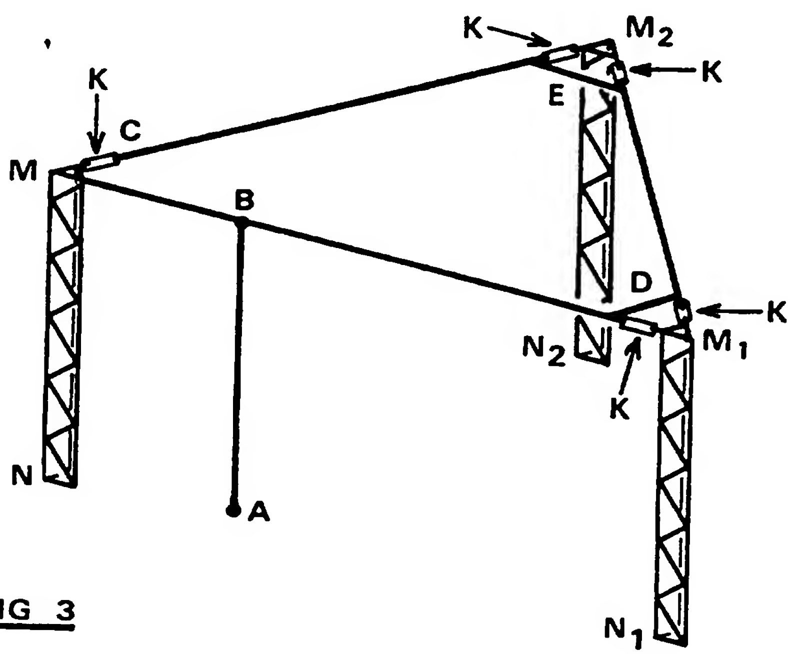

FIG 3

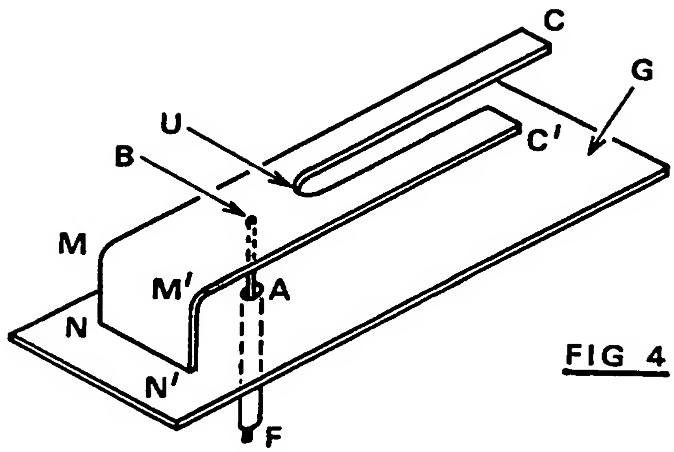

FIG 4

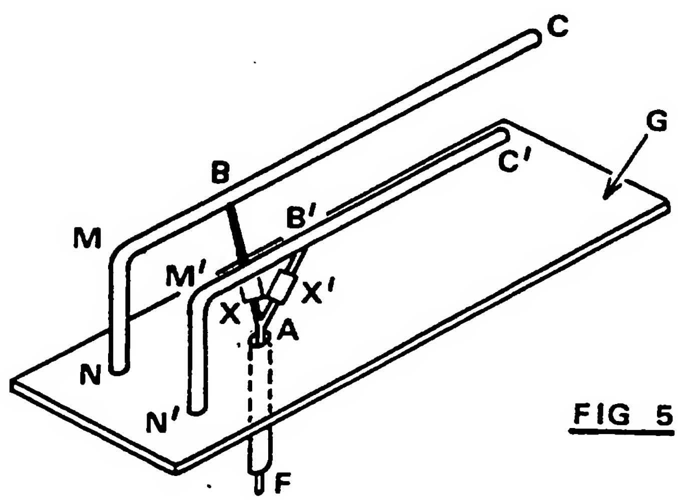

FIG 5

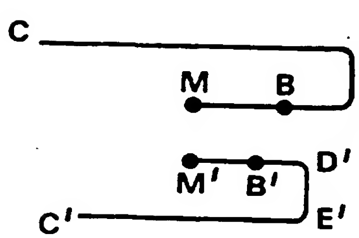

FIG 6

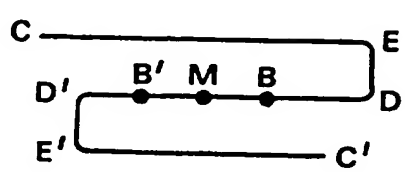

FIG 7